

CLAIMS

What is claimed is:

1. An apparatus for determining changes in the shape of an object comprising:
an electromagnetic radiation source coupled to the object, the
5 electromagnetic radiation source emitting a shaped beam, and
an array of electromagnetic radiation sensors coupled to the object to
receive radiation from the radiation source, responses of the sensors indicating
angular orientation of the shaped beam with respect to the array.
2. The apparatus of Claim 1 wherein the responses of the sensors indicate a
10 displacement of the shaped beam with respect to the array.
3. The apparatus of Claim 2 wherein the shaped beam has a substantially cross-
shaped cross-section.
4. The apparatus of Claim 1 wherein the electromagnetic radiation source is a laser.
5. The apparatus of Claim 1 wherein the electromagnetic radiation source is an
15 electromagnetic-radiation-emitting diode.
6. The apparatus of Claim 1 wherein the electromagnetic radiation source
comprises at least two electromagnetic radiation sources.
7. The apparatus of Claim 1 further comprising a processor processing the
responses of the sensors to determine bend and twist of the object.
- 20 8. The apparatus of Claim 1 wherein the array of electromagnetic radiation sensors

is non-linear.

9. The apparatus of Claim 1 further comprising an electromagnetic radiation focusing device positioned between the electromagnetic radiation source and the array of electromagnetic radiation sensors.
- 5 10. The apparatus of Claim 1 wherein the electromagnetic radiation is infrared, visible, or ultraviolet light.
11. The apparatus of Claim 1 wherein the object is a blade.
12. The apparatus of Claim 1 further comprising
a second electromagnetic radiation source coupled to the object, the
10 second electromagnetic radiation source emitting a second shaped beam, and
a second array of electromagnetic radiation sensors coupled to the object
to receive radiation from the second radiation source, responses of the sensors of
the second array indicating orientation of the second shaped beam with respect
to the second array.
- 15 13. The apparatus of Claim 12 wherein the object is a blade.
14. The apparatus of Claim 12 wherein the first shaped beam and the second shaped beam are substantially co-directed.
15. The apparatus of Claim 12 wherein the first shaped beam and the second shaped beam are substantially counter-directed.
- 20 16. The apparatus of Claim 1 wherein the changes in shape of the object are indicative of flow of a fluid around the object.

17. An apparatus for determining changes in the shape of an object comprising
a first electromagnetic radiation source coupled to the object, the first
electromagnetic radiation source emitting a first beam,
a first array of electromagnetic radiation sensors coupled to the object to
5 receive radiation from the first radiation source, responses of the sensors of the
first array indicating orientation of the first beam with respect to the first array,
a second electromagnetic radiation source coupled to the object, the
second electromagnetic radiation source emitting a second beam, and
a second array of electromagnetic radiation sensors coupled to the object
10 to receive radiation from the second radiation source, responses of the sensors of
the second array indicating orientation of the second beam with respect to the
second array;
the second radiation source being axially displaced along a length of the
object with respect to the first radiation source and the second array of sensors
15 being axially displaced along a length of the object with respect to the first array
of sensors to provide a combined indication of changes in the shape of the
object.
18. The apparatus of Claim 17 wherein the object is a blade.
19. The apparatus of Claim 17 wherein the first beam and the second beam are
20 substantially counter-directed.
20. A blade comprising
an electromagnetic radiation source coupled to the blade, the
electromagnetic radiation source emitting a beam, and
an array of electromagnetic radiation sensors coupled to the blade to
25 receive radiation from the radiation source, responses of the sensors indicating
orientation of the beam with respect to the array.

21. A method for determining changes in the shape of an object comprising:
emitting a shaped beam from an electromagnetic radiation source
coupled to the object, and
determining angular orientation of the shaped beam with respect to an
array of electromagnetic radiation sensors coupled to the object to receive
radiation from the radiation source, using responses of the sensors.
22. The method of Claim 21 further comprising determining displacement of the
shaped beam with respect to the array using responses of the sensors.
23. The method of Claim 21 wherein the shaped beam has a substantially cross-
shaped cross-section.
24. The method of Claim 21 wherein the electromagnetic radiation source is a laser.
25. The method of Claim 21 wherein the electromagnetic radiation source is an
electromagnetic-radiation-emitting diode.
26. The method of Claim 21 wherein the electromagnetic radiation source comprises
at least two electromagnetic radiation sources.
27. The method of Claim 21 further comprising processing the responses of the
sensors to determine bend and twist of the object.
28. The method of Claim 21 wherein the array of electromagnetic radiation sensors
is non-linear.
29. The method of Claim 21 further comprising focusing the electromagnetic
radiation using a focusing device positioned between the electromagnetic

radiation source and the array of electromagnetic radiation sensors.

30. The method of Claim 21 wherein the electromagnetic radiation is infrared, visible, or ultraviolet light.
31. The method of Claim 21 wherein the object is a blade.
- 5 32. The method of Claim 21 further comprising
emitting a second shaped beam from a second electromagnetic radiation
source coupled to the object, and
determining orientation of the second shaped beam with respect to a
second array of electromagnetic radiation sensors coupled to the object to
10 receive radiation from the second radiation source, using responses of the
sensors of the second array.
33. The method of Claim 32 wherein the object is a blade.
34. The method of Claim 32 wherein the first shaped beam and the second shaped beam are substantially co-directed.
- 15 35. The method of Claim 32 wherein the first shaped beam and the second shaped beam are substantially counter-directed.
36. The method of Claim 21 wherein the changes in shape of the object are indicative of flow of a fluid around the object.
- 20 37. A method for determining changes in the shape of an object comprising
emitting a first beam from a second electromagnetic radiation source
coupled to the object,

determining orientation of the first beam with respect to a first array of electromagnetic radiation sensors coupled to the object to receive radiation from the first radiation source, using responses of the sensors of the first array,

5 emitting a second beam from a second electromagnetic radiation source coupled to the object, and

determining orientation of the second beam with respect to a second array of electromagnetic radiation sensors coupled to the object to receive radiation from the second radiation source, using responses of the sensors of the second array;

10 the second radiation source being axially displaced along a length of the object with respect to the first radiation source and the second array of sensors being axially displaced along a length of the object with respect to the first array of sensors to provide a combined indication of changes in the shape of the object.

15 38. The method of Claim 36 wherein the object is a blade.

39. The method of Claim 36 wherein the first beam and the second beam are substantially counter-directed.

40. A method to determine changes in the shape of a blade comprising
20 emitting a beam from an electromagnetic radiation source coupled to the blade, and
determining orientation of the beam with respect to an array of electromagnetic radiation sensors coupled to the blade to receive radiation from the radiation source, using responses of the sensors.

41. An apparatus for determining changes in the shape of an object comprising:
25 a means for emitting a shaped beam of electromagnetic radiation, the

means for emitting electromagnetic radiation being coupled to the object, and
an array of means for sensing electromagnetic radiation, the array being
coupled to the object to receive radiation from the means for emitting
electromagnetic radiation, responses of the means for sensing electromagnetic
5 radiation indicating orientation of the shaped beam with respect to the array.

42. An apparatus for determining changes in the shape of an object comprising:
a first means for emitting a first beam of electromagnetic radiation, the
first means for emitting electromagnetic radiation being coupled to the object,
a first array of means for sensing electromagnetic radiation, the first array
10 being coupled to the object to receive radiation from the first means for emitting
electromagnetic radiation, responses of the means for sensing electromagnetic
radiation of the first array indicating orientation of the first beam with respect to
the first array,
a second means for emitting a second beam of electromagnetic radiation,
15 the second means for emitting electromagnetic radiation being coupled to the
object, and
a second array of means for sensing electromagnetic radiation, the second
array being coupled to the object to receive radiation from the second means for
emitting electromagnetic radiation, responses of the means for sensing
20 electromagnetic radiation of the second array indicating orientation of the second
beam with respect to the second array;
the second means for emitting a second beam of electromagnetic
radiation being axially displaced along a length of the object with respect to the
first means for emitting a first beam of electromagnetic radiation and the second
25 array of means for sensing electromagnetic radiation being axially displaced
along a length of the object with respect to the first array of means for sensing
electromagnetic radiation to provide a combined indication of changes in the
shape of the object.

43. A blade comprising
a means for emitting a beam of electromagnetic radiation, the means for emitting electromagnetic radiation being coupled to the blade, and
an array of means for sensing electromagnetic radiation, the array being
5 coupled to the blade to receive radiation from the means for emitting electromagnetic radiation, responses of the means for sensing electromagnetic radiation indicating orientation of the beam with respect to the array.
44. An apparatus for determining flow of a fluid around an object comprising
an electromagnetic radiation source coupled to the object, the
10 electromagnetic radiation source emitting a beam, and
an array of electromagnetic radiation sensors coupled to the object to receive radiation from the radiation source, responses of the sensors indicating orientation of the beam with respect to the array.
45. A method for determining flow of a fluid around an object comprising
15 emitting a beam from an electromagnetic radiation source coupled to the object, and
determining orientation of the beam with respect to an array of electromagnetic radiation sensors coupled to the object to receive radiation from the radiation source, using responses of the sensors.
- 20 46. An apparatus for determining flow of a fluid around an object comprising
a means for emitting a beam of electromagnetic radiation, the means for emitting electromagnetic radiation being coupled to the object, and
an array of means for sensing electromagnetic radiation, the array being
coupled to the object to receive radiation from the means for emitting
25 electromagnetic radiation, responses of the means for sensing electromagnetic radiation indicating orientation of the beam with respect to the array.